ASSESSMENT OF ISSUES AND ALTERNATIVES ASSOCIATED WITH PROPOSED GROUND WATER DEVELOPMENT NEAR GRAND CANYON NATIONAL PARK AT TUSAYAN, ARIZONA

-DRAFT-

United States Department of the Interior • National Park Service
Water Resources Division • Fort Collins, Colorado
September 17, 1993

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The Project Proposal

A private residential and commercial development is proposed near Tusayan, Arizona. The development plans include a proposed water well into the Redwall Aquifer. An analysis of ground water impacts from continuous pumping at 300 gallon per minute (gpm) was conducted for the developer by Errol Montgomery and Associates, Inc. That analysis concludes that springflow declines will occur at Indian Garden Spring and Hermit Spring in Grand Canyon National Park (GRCA), and at Havasu Spring on the Havasupai Indian Reservation. The magnitudes of projected springflow decline are 27 gpm at Indian Garden Spring, 5 gpm at Hermit Spring, and 269 gpm at Havasu Spring. This equates to 8.9 percent, 1.7 percent and 0.9 percent of the estimated total flow at the three springs, respectively.

Technical Issues Associated With the Regional Ground Water Flow Assessment

The approach to analyzing regional geohydrologic effects of ground water pumping at Tusayan was to: characterize the regional aquifer, geologically; estimate its hydraulic properties; and simulate water movement within the aquifer using a computer-based ground water model. The analysis was credibly and professionally conducted. However, its validity depends upon several critical assumptions. The most important of these assumptions involves the description of the hydraulic connectivity, through geologic fractures and solution cavities, within the aquifer. Specifically, the analysis portrays poor connectivity between the well site and Indian Garden and Hermit Springs, and comparatively good connectivity between the well site and Havasu Springs. These assumptions cannot be validated with existing information, but can greatly influence the prediction of springflow declines at Indian Garden and Hermit Springs. Specific aspects of the analysis are identified which could result in significant under-estimation of the potential effects of pumping on park springs.

Technical Recommendations

Technical recommendations fall into three classes: (1) modeling alternative ground water pumping scenarios, including locating the point of water withdrawal farther to the south; (2) modeling alternative hydrogeologic scenarios, including a "worst case" scenario whereby the Bright Angel Fault and Indian Garden Springs were

assumed to be effectively connected hydraulically through secondary fracturing with the well site at Tusayan; and (3) modification of the ground water development plans to provide for at least two wells, with at least one well located south in the Markham Dam fracture zone. In addition recommendations are provided for a monitoring well in the Bright Angel Fault and for a spring monitoring program for park springs.

Water Rights Considerations

The Case of Tusayan

National Park Service (NPS) policy holds that there are no resources within the boundaries of an NPS unit which can be viewed as "excess" or "surplus". As a result, the NPS is not in a position to give, sell, or otherwise dispose of natural resources.

Congress can, and occasionally does, direct the NPS to sell water. However, Congress generally attaches limitations to such sales. In the case of Tusayan, emergency water deliveries could be made only if: 1) the recipient provided important services to park visitors and was the only reasonably available source of such services; 2) the recipient had no other reasonable alternative source of water; and 3) there occurred no adverse environmental effect from providing the water. The NPS may presently be at odds with its own policy as it satisfies Tusayan's thirst.

Transfer of NPS Administration Facilities Outside of GRCA

A proposal for a substantial housing project on the periphery of the park in or near Tusayan has been placed before the NPS. This proposal fits with NPS plans to move facilities out of the park proper. However, the water resources of GRCA and, more immediately, the NPS's water rights will likely be impacted by the developer's well pumping. The impact, however, is hypothesized to be minimal with most of the effect occurring at Havasu Springs off NPS-administered lands.

Though impact might be minimal, the GRCA springs to be affected arise on lands reserved from the public domain. Arguably, a reserved water right attaches to them in the minimum amount necessary to prevent the defeat of reservation purposes.

Administrative and Other Water Needs

The necessity of providing for visitor and staff water needs does, on occasion, adversely affect NPS water resources and water-related resource values. The courts

have not generally been troubled by this because of the Service's dual preservation/public use mandate. However, use and impact have generally both been within the reservation.

Water Rights Alternatives

Alternative means of water rights issue resolution include:

A. Oppose water development as impacting NPS water rights

NPS would seek protection from any water use outside GRCA which adversely affects within-park resources and, therefore, NPS water rights.

B. Do not oppose water development but monitor springs for impact then seek relief if necessary

This would establish a monitoring program intended to identify impacts to NPS water resources. If impacts could be established to be related to water use outside of the park, then the NPS could take action through either the state or the court.

C. Oppose water development unless applicant can assure no impact

The NPS could offer to withdraw any opposition to the proposal if the developer agreed to move the proposed well to a location which would assure no effects would occur at GRCA springs.

D. Oppose water development unless applicant can assure no impact plus import GRCA water for use at new NPS administration facility

The assurance of no impact would be required but the NPS would provide its own water for an administration facility to be provided by the developer.

E. Support water development and allow spring flow depletion

The NPS would account for depletions in spring flow at GRCA by accounting for the water use by the NPS at the Administration facility. In effect, the NPS would be using its reserved water and the developer would be using Havasu Spring water.

Water Rights Conclusion

From the water rights perspective, Alternative E holds some promise for meeting NPS needs without running afoul of policy or reserved rights doctrine. The approach relies upon the idea that the NPS would account for spring flow depletion through use of its reserved right for reservation purposes. This would require that the quantities used would equate to no less than the depletion.

Whether Alternative E or some other approach is selected, legal counsel should review the plan and verify or reject the attached analysis before an action is initiated.

TECHNICAL ISSUES ASSOCIATED WITH THE ANALYSIS OF GROUND WATER PUMPING IMPACTS TO THE SPRINGS OF GRAND CANYON NATIONAL PARK

Introduction

Canyon Forest Village, Inc. is negotiating a land exchange with the U.S. Forest Service (USFS) as part of a residential and commercial development proposal near Tusayan, Arizona. The development plans include a proposed production water well into the Redwall/Muav Limestones at the "Airport Graben" fracture zone near Tusayan. The well would produce 300 gpm continuously, ultimately affecting discharges from the Redwall/Muav aquifers at springs in GRCA and the Havasupai Indian Reservation.

A ground water impact analysis was conducted for the developer by Errol Montgomery and Associates, Inc. That analysis concludes that long-term declines in spring flow from the aquifers will equate to the amount of pumping from the Airport Graben fracture zone. It further projects that the magnitude of spring flow declines will be 27 gpm at Indian Garden Spring, 5 gpm at Hermit Spring, and 269 gpm at Havasu Spring. This equates to 8.9 percent, 1.7 percent and 0.9 percent of the estimated total flow at the three springs, respectively.

The purpose of this report is to discuss the applicability of the Montgomery and Associates, Inc. analysis to NPS resource protection concerns, and to provide recommendations for additional geohydrologic assessments.

Regional Ground Water Flow Assessment

The approach taken by Montgomery and Associates, Inc. to analyzing regional geohydrologic effects of ground water pumping at Tusayan was to: (1) characterize the regional aquifer, geologically; (2) estimate its hydraulic properties; and (3) simulate water movement within the aquifer using a computer-based ground water model.

Geologic characterization of the regional aquifer requires an identification of the geologic formations functioning as the aquifer of concern, including the aerial extent and thickness of the aquifer, structural features affecting the movement of water within the aquifer, and locations and amounts of aquifer recharge and discharge. Aquifer hydraulic properties of concern include the amount of water stored per unit volume of aquifer (storativity), transmissivity (or hydraulic conductivity), and water-table surface elevations and water table gradients (the hydraulic "head" caused by differences in water table elevations).

In characterizing the regional aquifer for purposes of their analysis, Montgomery and Associates, Inc. relied heavily on published descriptions of the regional geology, and published values of the discharges at Hermit, Indian Garden and Havasu Springs. Virtually no well data exist on which to base estimates of storativity, transmissivity, or water-table elevations. These parameters had to be assumed and/or estimated through model calibrations.

Hydrogeology

The geologic work of Metzger (1961) and Huntoon, et al. (1986) formed the basis for the geologic characterization of the Regional aquifer. The aquifer is described as consisting of three geologic formations: the Redwall, Temple Butte, and Mauv Limestones. These water transmitting zones are underlain by the Bright Angel Shale, which acts as an aquitard. "Leakage" from the Redwall formation is the primary source of springs in formations below in the Grand Canyon.

The limestones, comprised primarily of calcium and magnesium carbonates, generally are poor transmitters of water except along fracture zones and through solution cavities. Thus, Montgomery and Associates, Inc., identified the primary fault-induced regional fractures as identified by Huntoon, et al. (1986) and Metzger (1961) as the principal pathways for water recharge, storage and movement within the aquifer (Figure 1). These structural features were defined from surface geologic mapping. This appears to be a valid conceptualization of the regional aquifer. However, other faults which do not intersect the land surface could exist and be very important in ground water movement.

The descriptive model of the aquifer system shows the Havasu Downwarp and the Vishnu and Redhorse fault systems as interconnected with the Markham Dam fracture zone, but the Bright Angel and Redlands faults as disconnected. The basis for this assumption is not provided and its validity cannot be confirmed. However, as discussed below, the accuracy of this assumption may be important in defining the response of the springs to pumping elsewhere in the aquifer.

The Havasu Downwarp is described by Metzger (1961) and interpreted by Montgomery and Associates, Inc. as having large transmissivity and storativity and as the likely source for the large spring at Havasu. The "Markham Dam Fracture Zone" is described in the Montgomery and Associates, Inc. report as a large zone of recharge and water storage for the regional aquifer. Older reports do not mention this large reservoir, but it is also very deep and possibly beyond the limits of previous exploration. Interconnection of this reservoir with springs and the hydrogeologic function of faults has not been previously documented. Again, both the existence of this important recharge/reservoir zone and the existence of an effective hydraulic connection to the Vishnu fault and Airport Graben, is difficult to validate but critical to the prediction of aquifer response to ground water pumping.

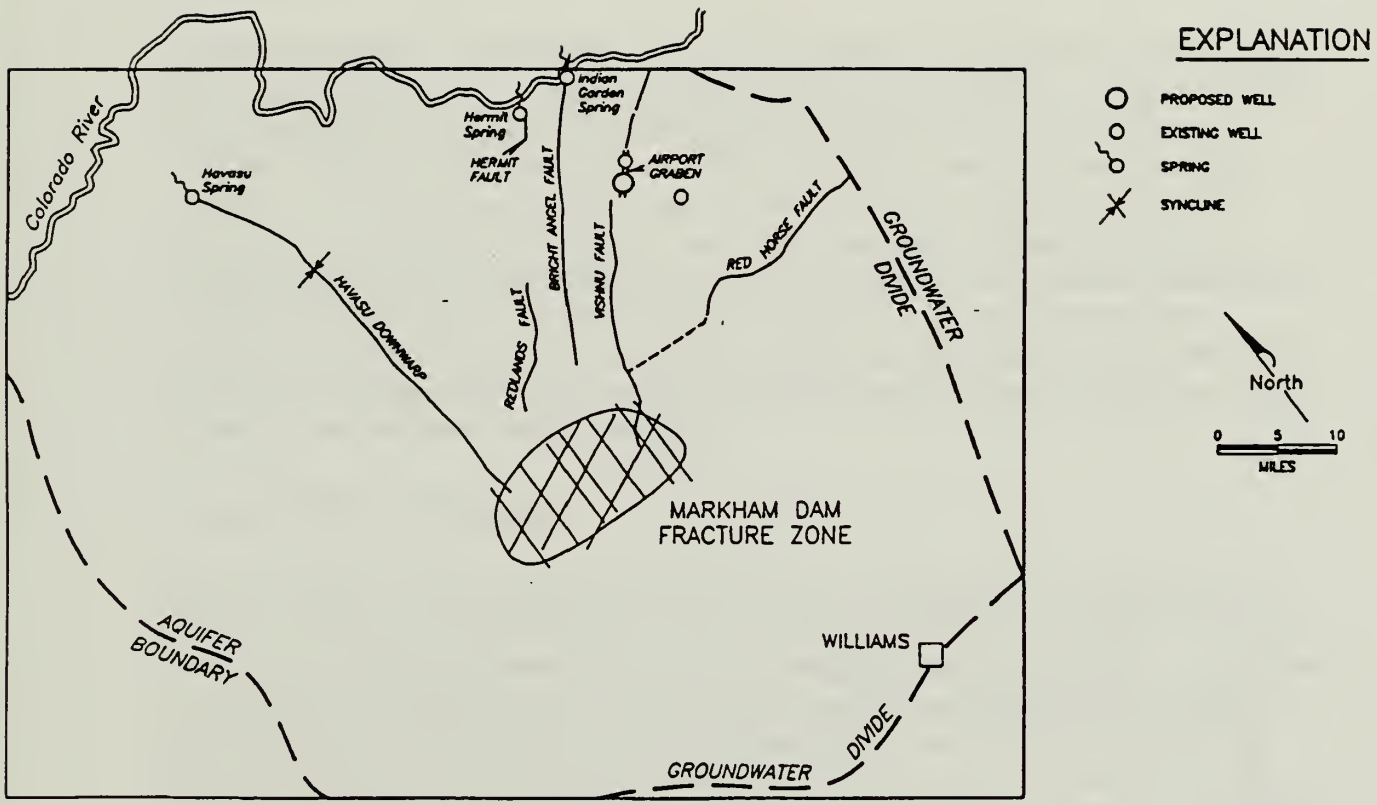

Figure 1. A conceptualization of the regional aquifer, indicating principal fracture zones (from Errol L. Montgomery and Associates, Inc., 1993).

Both Hermit and Indian Garden springs are described as associated with fracture zones that are not interconnected with either the Vishnu Fault, or the Airport Graben. Again, the validity of this assumption cannot be confirmed. However, it is very probable that, in addition to the primary fracture zones depicted in the descriptive model of the regional aquifer, there exist hundreds of secondary fractures and solution cavities. It may be impossible to meaningfully characterize secondary fracturing in the regional aquifer or to account for its hydraulic effects within the context of a regional ground water model. However, secondary pathways may be very important in evaluating aquifer response to ground water pumping in specific locations; and especially in locations assumed to be poorly connected hydraulically, to primary zones of water storage and movement.

Hydraulics

The virtual absence of wells into the regional aquifer, and associated pumping tests, makes it impossible to characterize directly the hydraulic attributes of the aquifer. It is assumed that storativity and transmissivity values for the non-fractured Redwall/Muav complex were derived from published values for other limestone aquifers. It is further assumed that water-table elevations, and storativity and transmissivity values for the fracture zones were initially estimated and then calibrated/adjusted through modeling to permit replication of measured discharges at Hermit, Indian Garden and Havasu Springs. This is a rational approach to developing hydraulic attributes in absence of data, but the validity of the estimates cannot be confirmed and are severely dependent upon the conceptualization of the primary flow pathways within the aquifer.

Ground Water Modeling

MODFLOW, a three-dimensional, finite-difference computer model developed by the U.S. Geological Survey (McDonald and Harbaugh 1988) was applied to replicate pre- and post-pumping groundwater flow through the Regional Aquifer. The model is applied by overlaying a grid on the regional aquifer and assigning the aquifer in each grid values of recharge, storativity, transmissivity and water-table elevation. Water then flows between grids according to the laws of porus media flow. When inflow to a grid is not balanced by outflow from the grid, the difference is reflected as a change in water-table elevation, either increasing or decreasing. Flows between grids are calculated continuously over fixed-time increments until water-table elevations become steady and grid inputs equate to grid outputs.

For the pre-pumping condition, it is believed that recharge to the aquifer was assumed to occur primarily along fracture zones, including the Markham Dam area, and at rates equivalent to the combined annual discharge of Hermit, Indian Garden and Havasu Springs. The model was calibrated by adjusting the distribution of

recharge and transmissivity until observed spring discharges were replicated. This condition would also define water-table elevations within the model grids. Montgomery and Associates, Inc. were able to verify model-predicted water table elevations at a single well at the Canyon Mine.

Given a model representing a conceptual description of the aquifer and "calibrated" to the pre-pumping condition, it is next assumed that the model can predict a response of the aquifer to pumping. Montgomery and Associates, Inc., ran the model under conditions of pumping from the Airport Graben until a new steady-state condition (in terms of water table elevations) was achieved (estimated to take more than 50 years). This new equilibrium condition then defined new water-table elevations and gradients, and changes in discharges at the three springs.

Assuming that an accurate conceptual description of the aquifer has been developed (this is a critical assumption, further discussed below), the modeling approach of Montgomery and Associates is credible and represents standard professional practice. The application of a "porus media" model to a fracture flow situation also is acceptable given the large regional area being modeled.

Technical Issues Associated with the Regional Ground Water Flow Assessment

Given the extreme lack of quantitative information on flow paths, aquifer characteristics and water-table elevations, it can be concluded that Montgomery and Associates, Inc. did as credible a job as reasonably possible of defining the aquifer system and assuming its appropriate hydraulic characteristics. Montgomery and Associates, Inc. argue credibly that the quality of information on spring outflows from the aquifer in part compensate for the lack of data on hydraulic characteristics. However, the validity of the modeled impacts of pumping on springs is strongly dependent upon the validity of the calibrated regional model as it was developed for the pre-pumping condition. The calibrated "pre-pumping" model, in turn, is dependent upon the accuracy with which the regional aquifer and its associated fractured-flow system has been characterized.

The characterization of flow paths (associated with primary and secondary faulting within the regional aquifer) is critical to the development of a meaningful predictive model of water movement within the regional aquifer. Furthermore it is virtually impossible to confirm or validate that the aquifer characterization developed by Montgomery and Associates, Inc., is, in fact, precise enough to permit an accurate depiction of pumping effects on spring flows. It is important to appreciate that alternative aquifer characterizations could be offered, which also could be calibrated to the pre-pumping condition, but which would yield widely different predictions of pumping impacts to springs. Unfortunately, we have no way with given data to

validate the model developed for the pre-pumping condition. This stands as the most significant point of concern with the analysis presented by Montgomery and Associates, Inc.

Assumptions which necessarily went into the characterization of flow paths within the regional aquifer cause concern that the model as presently constructed could misrepresent the potential impacts of pumping on Grand Canyon Springs. Probably the most significant of these assumptions is that Hermit and Indian Garden springs are associated with faults which are **not** connected to the Vishnu Fault, the Airport Graben or the Markham Dam fracture zone. The assumed lack of effective hydraulic connection between these springs and the Airport Graben serves to "force" the model to draw water from the Vishnu Fault and Markham Dam areas, while minimizing drawdowns in the Bright Angel and Hermit faults.

The second important assumption is that the Airport Graben/Vishnu Fault zones are effectively connected to and recharged by the reservoir assumed to underlay the Markham Dam fracture zone. This assumption is critical for three reasons. First, it permits effective recharge to the Airport Graben during pumping, thus enabling pumping to continue indefinitely at 300 gpm. Second, it minimizes the amount of drawdown in the Airport Graben caused by pumping, further minimizing impacts to local springs. Third, it draws most recharge water from the Markham Dam region; water that primarily is destined to discharge at Havasu Springs.

A third critical assumption is that the Markham Dam fracture zone is, in fact, a significant recharge area for the regional aquifer, and that a significant reservoir of water underlies this zone, and that the reservoir currently is being recharged by infiltration of precipitation. It is the existence of this large fracture zone, in combination with the assumed efficient hydraulic connection to the Airport Graben, which largely causes the model to predict a minimal impact to Hermit and Indian Garden springs, while drawing most recharge water from the Markham Dam/Havasu Downwarp/Havasu Spring area.

Recommendations

In this section, recommendations are offered which the Water Resources Division thinks would enhance the level of ground water analysis available during the project planning phase, and which would raise the level of assurance that planned water developments would have negligible impacts on park water resources. Recommendations fall into three classes: (1) modeling of alternative ground water pumping scenarios, (2) modeling of alternative hydrogeologic scenarios, and (3) modification of ground water development plans to provide for pumping contingencies and monitoring.

Alternative Ground Water Pumping Scenarios

Locating pumping at the Airport Graben near Tusayan maximizes the amount of drawdown in the vicinity of Grapevine and Indian Garden Springs. It also maximizes the amount of drawdown required in the Vishnu Fault/Markham Dam zones. By locating the well either south in the Vishnu Fault, further south in the Markham Dam fracture zone, or west in the Havasu Downwarp, pumping impacts on NPS springs would be minimized and the likelihood of recharge to the pumping zone from assumed major regional aquifer recharge areas is maximized. At a minimum, alternative well locations 10 miles and 20 miles south of Tusayan should be modeled with the computer model as presently developed and calibrated.

Alternative Aquifer Conceptualization Scenarios

A "worst case" aquifer conceptualization scenario from the standpoint of potential pumping impacts to park springs should be constructed and modeled. At a minimum, fracturing in the Redwall/Mauv Aquifers should be redefined to show hydraulic connection via secondary fracturing between the Bright Angel Fault and the Airport Graben/Vishnu Fault. Also, secondary fracturing between the Bright Angle Fault and the Markham Dam fracture zone should be assumed to exist. Given a modified conceptualization of the aquifer, the model should be calibrated for the pre-pumping condition and run for pumping locations at Tusayan, and both 10 and 20 miles south of Tusayan.

Modified Water Development Plan

The present ground water development plan forwarded by Canyon Forest Village, Inc., provides for a single 300 gpm well in the Airport Graben at Tusayan. In addition to the potential risk to park springs, this plan presents risk to the developer should any problems arise regarding estimates of well yields. Given the number of assumptions inherent in the characterization of the regional aquifer, it would seem prudent to think in terms of developing a well "field," consisting of at least two to three wells. By strategically locating a small series of wells, it would be possible to utilize non-pumping wells as monitor wells, to further validate and refine assumptions in the ground water model and assess actual impacts to the hydrogeologic system from pumping. It also might provide an opportunity to define drawdown limits at any one well, which could serve to trigger pumping at another well, thus providing both water supply contingencies and spring protection contingencies. It is difficult to recommend precise locations for a series of two to three production wells, but from an NPS perspective, it would be preferable if at least one well were located in the Markham Dam fracture zone (if for no other reason than to confirm its existence and geohydrologic properties).

Given the critical nature of the Bright Angel Fault in supplying water to park spring(s), it would be desirable to construct a monitor (non-producing) well in the Bright Angel Fault to further validate predicted pumping effects and to provide a basis for limiting or allowing additional pumping. Any constructed wells in the vicinity of the South Rim, whether for production or monitoring purposes, should be constructed with casing sealing to eliminate the possibility of impacting perched aquifers encountered during drilling. These perched aquifers may be important for maintaining small springs and seeps located in the park above the Redwall formation.

Finally, in Appendix I, an approach for implementing monitoring at critical NPS springs is recommended.

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Background

To adequately assess issues and alternatives, a rudimentary understanding of water rights is needed. For the purposes of this document the discussion will be limited to Arizona Appropriated Water Rights and Federal Reserved Water Rights.

Arizona Appropriated Water Rights - Surface Water

The state of Arizona has followed a more-or-less traditional course in the development of its water law. Specifically, like most western states, Arizona embraced the Doctrine of Prior Appropriation. This means that the use of water is based upon statutory recognition of the phrase, "first in time, first in right." A right to the use of water is created by the act of taking and placing water to a beneficial use. The first party beneficially using water secures a right which is superior to the rights of subsequent users.

This right is a property right whose ownership may change as well as its location of diversion and use, so long as no injury occurs to other appropriators. The term "beneficial use" is of critical importance because no water right attaches to a use of water unless that use is recognized as "beneficial" by state law. Further, beneficial use is the basis, the measure and the limit of the water right. No right attaches to more water than is actually used beneficially, neither does a right attach to waste. In addition, the right can be forfeited if the use is intentionally abandoned.

Western water rights are usufructuary; this means the right attaches only to the use of the water, not the corpus or body of the water. Ownership of the body remains with the state. With this the case, the state maintains authority over water appropriation and use and establishes rules and regulations governing its use, the protection of other users, and guarding the public welfare/interest. This was codified in 1919 when Arizona adopted a permit system requiring that all water rights be developed by first making application to the state for a permit to appropriate.

Under all circumstances, water use by a junior priority-holder can occur only to the degree that it does not interfere with the rights of a senior. By the same token, a senior may make changes in water use only to the degree that they do not interfere with the rights of juniors. Once injury is evidenced, the aggrieved party may seek relief through either the state's administrative procedures or court, as appropriate.

Arizona Appropriated Water Rights - Ground Water

State laws governing the appropriation and use of ground water vary more from state to state than do laws for surface water. Arizona's ground water law is one of the more complex ones among the western states. State administration of ground water use began with the passage of the state's Groundwater Management Act in 1980. Arizona's administrative approach relies upon the recognition of three types of ground water; **percolating, subflow, and water flowing in defined underground channels.** The first, **percolating,** is the ground water typically found in confined and unconfined aquifers. Percolating ground water is not regulated by the state (see exceptions below) and a landowner may take and use it as a right of land ownership. While use of percolating ground water is not presently regulated, Arizonans using such ground water have been asked by the state to register their wells for informational purposes.

Subflow is that water below the surface of the land which is in physical connection with surface water. It is most generally that water which occupies the interstitial spaces in stream alluvium and is characterized by varying volume and areal extent as the occurrence of surface water varies. Because subflow affects and is affected by surface water availability, it is governed by the same rules as for the connected surface source. This means an appropriator of subflow is limited by the same rules of priority, beneficial use, etc., as the surface water appropriator in that source.

The third category, **water flowing in defined underground channels,** is the least commonly encountered of the three. Underground flow paths do exist, typically in carbonate aquifers and karst land forms where solution cavities are common, but they tend to be fairly rare, particularly in Arizona. Where they do exist, the rules of prior appropriation apply. Appropriations must be made within the same confines of water law as apply to surface water appropriations; however, they differ in that the elements are operative only upon appropriators using the same source, the underground channel flow.

As with surface water, water use by a junior priority-holder can occur only to the degree that it does not interfere with the rights of a senior. Again, like surface water, a senior may make changes in water use only to the degree that they do not interfere with the rights of juniors. Also like surface water, once injury is evidenced, the aggrieved party may seek relief through the state's administrative procedures or court, as appropriate. Having said this, it should be noted that ground water injury cases are extremely complex and difficult to prove. Stated another way, he who bears the burden of proof in ground water cases loses.

Exceptions to the general statements above occur with respect to "Irrigation Non-expansion Areas" (INA), "Active Management Areas" (AMAs) and ground water use affecting, or affected by, **Federal Reserved Water Rights** (see below). The state

establishes these management areas generally where water supply is in jeopardy due to high use or impaired quality. Within AMAs all ground water withdrawals are subject to state administration, regardless of type. INAs were established to prohibit the enlargement of the acreage irrigated with ground water beyond that irrigated 5 years prior to designation.

A use of percolating ground water which affects a federal reserved right may not be exempt from state water law administration. The issue, to the best of our knowledge, has not been litigated. Nevertheless, one district court has taken the position that such ground water use must be treated differently because of the federal right.

Federal Reserved Water Rights

When the western United States was settled, the federal government was silent as to federal interests in water. As a result, the states individually developed bodies of law to address the use of water within state boundaries. When a conflict finally arose between the operation of state water law and the use of water for congressionally mandated purposes on federal land, the U.S. Supreme Court created the **Doctrine of Federal Reserved Water Rights.**

In essence, the Doctrine recognized the right of the federal government to the amount of water necessary for the purposes of a federal reservation of land from the public domain. This water was to come from water unallocated at the time the reservation was created. The water "reserved" for federal use was to be the minimum amount necessary to prevent defeat of the federal reservation purpose, no more. The priority date for the reserved right arose as of the date of the land reservation, even if the water was not used until some time later. The right could not be lost due to non-use and it was not required to conform to state-defined beneficial uses. The federal use, however, would remain junior to those uses initiated prior to the creation of the federal reservation.

The federal reserved water right may or may not extend to ground water. The uncertainty exists because the issue has not been addressed by the Court. Having said that, it is instructive to note that the U.S. Supreme Court enjoined the pumping of ground water when that pumping affected a pool with a reserved right for the protection of Pup Fish.[1]

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[1] Cappaert v. United States, June 7, 1976; 426 US 128.

The Process of Adjudication

The existence of a federal water right is one thing, but its relationship to all other water rights is another. The purpose of water law is to reduce uncertainty. A water right carries with it intrinsic value because it provides its holder with more or less certainty that water will be available during times of shortage. The creation of unquantified federal water rights with senior priority dates, which existed even if never put to a beneficial use, has resulted in heightened uncertainty for other water users.

Absent the federal rights, uncertainty about water rights is generally removed by a court procedure called **adjudication**. The process involves a court determination as to the legal entitlement of claimants to water rights. Normally, the federal government does not participate in such court proceedings. However, in 1952 the McCarran Amendment[2] created a limited waiver of Sovereign Immunity for purposes of a water rights law suit where the United States is or could be a claimant of water rights and was a necessary party to a basinwide adjudication.

During an adjudication, the United States puts on testimony as to the merits of its claims to water rights, both appropriated and federal reserved. Once completed, the process establishes the United States's rights for all time. Most of the state of Arizona[3] is presently going through the adjudication process following a basin-by-basin progression. NPS claims of water rights in GRCA springs, etc., will be addressed in the adjudication process at some future time.

Any NPS decisions with regard to the use of water from within GRCA, by NPS or any other entity, must conform to state and federal water law. This is especially important with regard to the federal reserved water right. With the right generally being implied and a creation of the Court, its form has changed over time through court interpretation; given time, it is likely to change further. Therefore, it is important that NPS actions not lead to the creation of a harmful precedent.

Issues

With the foregoing background to help understand the water rights aspects of the issues before managers at GRCA, a review the issues from the water rights perspective is needed.

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[2] Act of June 10, 1952; 66 Stat 560; 43 U.S.C. § 666

[3] Excluding the Colorado River and certain other basins (e.g., Rio Sonoyta).

The Case of Tusayan

The city of Tusayan is of particular interest here for two reasons: first, it is the location to which the present proposal applies, and many issues devolve from that fact; and second, the U.S. Congress has passed a law to specifically address the use of water from GRCA to meet an "emergency need" at Tusayan.

It is important to note at this juncture, that NPS policy is established with respect to the use of natural resources outside of park boundaries. Concisely stated, the policy holds that there are no resources within the boundaries of an NPS unit which can be viewed as "excess" or "surplus". As a result, the NPS is not in a position to give, sell, or otherwise dispose of natural resources. This is not to say, however, that such disposal doesn't exist. Tusayan is a case in point.

After Tusayan experienced a water supply crisis, the Congress passed a law in 1978[4] directing the NPS to sell water to a non-profit entity within Tusayan upon the Secretary of the Interior's determination that such sale would not be detrimental to the protection of the resources of GRCA. According to existing law[5], emergency water deliveries could be made only if three conditions were met: 1) the recipient provided important services to park visitors and was the only reasonably available source of such services; 2) the recipient had no other reasonable alternative source of water; and 3) there occurred no adverse environmental effect from providing the water (see attached summary report).

The emergency character of the congressional action is worthy of note. So too, is the fact that water was to be supplied only if reasonable alternatives were not available. As things stand now, the emergency character of the need is debatable as is the lack of a reasonable alternative. Tusayan continues to grow. This is counter-intuitive for a city experiencing a water shortage which necessitates emergency water deliveries. In addition, the successful development of a producing water well (drilled by the Squire Inn) raises the argument that an alternative water supply does exist. For these two reasons, at least, the NPS may presently be at odds with its own policy as it satisfies Tusayan's thirst. Of course, Congress could make the delivery requirement permanent. However, it has not yet chosen to do so.

Transfer of NPS Administration Facilities Outside of GRCA

A proposal for a substantial housing project on the periphery of the park in or near Tusayan has been placed before the NPS. The proposal differs somewhat from

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[4] PL 95-586, Nov. 3, 1978; 92 Stat. 2495.

[5] PL 91-383, Aug 18, 1970; 84 Stat. 825, later amended by PL 94-458 Oct. 7, 1976; 90 Stat. 1939.

typical park-adjacent development plans. For one thing, the developer plans to develop his own water supply; for another, the developer proposes a land swap with the USFS; and for a third, the development might include housing and administration facilities for NPS staff.

This proposal fits with NPS plans to move facilities out of the park proper. However, even though the developer proposes drilling a well or wells to supply needed water, the water resources of GRCA and, more immediately, the NPS's water rights, will likely be impacted by well pumping. The developer, through his consultant, admits that well pumping will diminish spring flows within GRCA. However, the impact is hypothesized to be minimal with most of the effect occurring at Havasu Springs off NPS-administered lands.

The NPS apparently faces a conundrum; on the one hand its policy prohibits giving or selling water, and congressional direction on water deliveries describes a very limited set of circumstances which suspend prohibitions and allow delivery. On the other hand, the NPS seeks to move staff and administration facilities out of the immediate park area for resource protection and to satisfy pressing staff housing needs.

To further complicate matters, the GRCA springs which would be affected arise on lands reserved from the public domain. Arguably, a reserved water right attaches to them in the minimum amount necessary to prevent the defeat of reservation purposes.

Administrative and Other Water Needs

The courts have recognized that the NPS has a right to water for both environmental and administrative reasons. Court battles generally revolve around questions about the NPS's entitlement to, and quantification of, water for non-typical, or environmental, uses. The water used for administrative purposes such as housing, offices, and visitor services is rarely questioned. This kind of use mirrors what happens under state law and state administrators are very familiar with amounts, purposes, and other specifics of such water use. While reserved rights for administrative purposes are rarely at issue, water use in these circumstances has generally occurred within the federal reservation, on reserved land, and for "reservation purposes." The use of reserved rights on non-reserved land, even though for reservation purposes, may be disallowed by the court.

While it is certainly not the NPS's intent, the necessity of providing for visitor and staff water needs does, on occasion, adversely affect NPS water resources and water-related resource values. The NPS goes to great lengths to avoid such effects, but is often left without alternatives. The courts have not generally been troubled by this circumstance, from a water rights perspective, because of the Service's dual

preservation/public use mandate. However, use and impact both generally been within the confines of the reservation.

Alternatives

With the preceding, admittedly oversimplified, review of the issues to be addressed by GRCA managers, a description of alternative means of water rights issue resolution is in order.

A. Oppose water development as impacting NPS water rights

This, the first alternative to be considered, is the simplest. Specifically, the NPS would seek protection from any water use outside GRCA which adversely affects within-park resources and, therefore, NPS water rights. This protection might be sought prior to well development to prevent impact as opposed to after development to mitigate impact.

B. Do not oppose water development but monitor springs for impact then seek relief if necessary

This alternative would put the NPS in the position of not opposing development in Tusayan but would establish a monitoring program intended to identify impacts to NPS water resources. If impacts were detected and could be established to be related to water use outside of the park, then the NPS would take action through either the state or the courts.

C. Oppose water development unless applicant can assure no impact

The developer contends that an almost imperceptible decline in NPS springs will result from the proposed water development. The NPS could offer to withdraw any opposition to the proposal if the developer agreed to move the proposed well to a location which would assure that impacts occurred only at Havasu Spring, thus protecting GRCA springs.

D. Oppose water development unless applicant can assure no impact plus import GRCA water for use at new NPS administration facility

This alternative is a variation upon the one previous. The assurance of no impact would still be required but the NPS would provide its own water for an administration facility to be built by the developer.

E. Support water development and allow spring flow depletion

The NPS would agree to the proposed development but would account for

Alternative B

This alternative would leave the NPS out of the picture with respect to taking a position on Tusayan growth. Activities beyond park borders would not be addressed by the NPS until a reasonable case to be made for stopping injurious actions. Water rights questions would be left unaddressed until there is actual need as evidenced by data demonstrating injury. Development which could benefit the NPS in terms of moving administration and housing out of the park could go forward and injury to NPS springs might never occur. If injury did occur, the NPS could rely upon its monitoring data to seek mitigation.

As noted before, proving injury to springs from ground water use is difficult, at best. The necessary data would probably be expensive and many years of collection might be necessary to demonstrate any statistically significant relationship between pumping and effect. In addition, once an effect were manifest, damage might not be reversible.

While this alternative would not, in itself, result in an adjudication, the NPS is presently party to the statewide adjudication process and will eventually participate. With this the situation, the NPS will have to present a case in court to establish entitlement to reserved rights for park purposes and then to quantify that right. The process of quantifying the minimum amount of water necessary for park purposes is difficult, and would likely be made more so if it could be demonstrated that water from the park were being used for purposes outside the ambit of the reserved rights doctrine.

This alternative represents what is typically seen in the west; the appropriator takes a chance that a senior water right holder will be injured and, as a result, "call the river" effectively foreclosing the new appropriation in all but the wettest years. In this context, the alternative conforms with western water law. However, as stated above, once effects become visible, consequences may be unacceptable and remedies more costly and difficult.

Alternative C

This alternative also sidesteps the issue of Tusayan growth. It does, however, strive to avoid impact at GRCA springs. It would not likely impede the development of the NPS administration facility, if the developer meets the requirement of no impact at GRCA.

This alternative would simplify the water rights question; no water reasonably covered by the reserved rights doctrine would be used. At the same time an alternative water supply would be developed and Tusayan could seek an alternative water source.

pp 17 & 18 are in reverse order

depletions in spring flow at GRCA by accounting for the water use by the NPS at the administration facility. In effect, the NPS would be using its reserved water and the developer would be using the Havasu Spring water.

Analysis of Alternatives

The following considers each alternative in turn, giving a little more depth to the analysis. Generally, the discussion looks at a positive or "upside" analysis followed by a negative or "downside" analysis.

Alternative A

This position could be viewed as the "moral high ground" by some. The successful pursuit of this alternative would prevent the proposed development. This would assure that this particular proposal would not succeed and spring flow within GRCA would remain unaffected by water withdrawal. At first blush, this would appear to be the preferred choice to prevent adverse impact.

The alternative is consistent with policy, vis-a-vis opposing, or at least not supporting, the additional development in Tusayan which could increase pressure upon limited water resources and thereby eventually affect springs within the park. In the event the NPS determines there is no longer a necessity for water delivery to Tusayan, the Service could point to this alternative as consistent with that position.

However, this ignores the park's assessment of the impacts produced by having administration facilities and housing inside the park. It also presumes an effective water rights remedy to stop the project. From the water rights perspective, trying to stop the project for the purpose of preventing injury to NPS water rights could be an extremely difficult exercise. Recalling the background discussion above, an action over injury to water rights is generally brought **subsequent to injury**, rather than in anticipation of injury. In addition, as stated above, ground water injury cases are extremely complex and difficult to prove with the plaintiff bearing the burden of proof.

An additional difficulty arises in the fact that the reserved rights at GRCA have yet to be quantified in a basinwide adjudication. This process tends to be lengthy, costly, and less than predictable. Opposing the project on the grounds of expected injury to NPS reserved rights could necessitate the establishment and quantification of those rights in an adjudication, the only forum for which a limited waiver of Sovereign Immunity exists for the purpose of a law suit to adjudicate water rights.

A shortcoming of this approach lies in the likelihood that no alternative location which eliminates NPS concerns can be found. The "Airport Graben" is a geological formation that is key to the water development proposed; no other formation has been identified so alternatives may be difficult or impossible to find. If this is true, then there may be no site that could produce water without affecting NPS springs.

Both now and for some time into the future, the location and magnitude of effects will be matters of speculation only. The NPS will have no certainty that GRCA springs are truly protected. Even if they were, and all flow was "pulled from" Havasu spring, there would be impacts **someplace** and **someone** would have to be willing to accept them.

Alternative D

As stated earlier, this alternative looks like Alternative C with the addition of the NPS providing its own water for the administration facility. While the comments on Alternative C apply here, they can be somewhat tempered. With the NPS providing its own water, theoretically there would be less demand upon the developer's well. This reduction in demand would presumably be reflected in decreased impact to NPS springs. Because it would use lowest impact approaches for water development and delivery to the administration facility (piped from existing developments or supplied from a new well drilled on reserved land) , the NPS could position itself to take aggressive action in the event impacts from non-federal well use were detected at GRCA springs.

The NPS could claim that its use of GRCA water falls under the aegis of the reserved right. Water use at administration and housing facilities could easily fit the definition of a use necessary to prevent the defeat of the "reservation purpose". However, the question would remain, "does the right extend to **non-reserved lands** even though reservation purposes are being served and the water source lies on reserved lands?"

While the supplementation of water supply **may** reduce impacts at GRCA, based upon the existing state of knowledge there can be no assurance of that. There is no technical reason to believe that the reduced impact won't benefit Havasu Springs instead. There is also no reason to believe that growth will not occur to the point of utilizing any savings caused by the NPS's use of other water.

Alternative E

According to the developer's consultant, the depletion effects at NPS springs would not be quantitatively large. However, the effects would be of greater consequence at GRCA than at Havasu because the **relative** effects would be larger (as a percentage of spring flow). With this the case, the actual depletion might equate to the amount of

water used by the NPS administration facility. If so, the NPS could claim that water use under the aegis of the reserved right, leaving the remainder to be claimed by the developer under state law as percolating water, though actually tributary to Havasu Spring.

While this approach is neat and simple, it is not without pit-falls. Specifically, NPS use should match depletion within the park. If the NPS use were less, then it would have to be assumed that the United States reserved water right was being injured by non-reservation uses. Under this circumstance the NPS would be expected to take action to effectuate a reduction in use, at least to the point of no injury. If, on the other hand, NPS use was greater than depletion, the difference could be viewed as coming from the developer's right.

The question of reserved right water use off the reservation would remain. Only litigation will resolve this question and there is no telling when the issue will be litigated, if ever.

The NPS could be silent on the Tusayan water use question until such time as a proven alternative water supply becomes established; at that time the NPS could declare the emergency need for water to be at an end. As to growth, the development of additional water sources that do not affect GRCA resources would not likely occur. The reasoning is, the developer's well would not affect GRCA springs only because the effect would be accounted for through NPS's use, under the aegis of a reserved right, at the administration facility. Any additional use could not claim such a rationale to justify impact; and, because some impact would be expected, some injury to NPS reserved rights would thus be unavoidable.

While all the alternatives discussed should be fully examined, for reasons which may seem obvious, Alternative E appears to be the most efficacious.

Conclusion

As most who have considered it have determined, the NPS faces several difficult and conflicting issues at GRCA. First, Tusayan has long been receiving an "emergency" water supply from GRCA. Such water delivery may have long term impacts to resources and may be supporting increased growth in Tusayan. Second, the NPS has determined that it is in the interest of resource protection to move at least some administration and housing facilities outside of the park. These facilities will need water which could further complicate the Tusayan water supply issue. Third, a proposal to develop ground water near the park could go forward, from a water rights perspective, because Arizona law does not require a permit to develop percolating ground water. Finally, the NPS must be consistent with its policies for resource protection and for water rights use and protection.

The nexus of these disparate issue appears to be the fact that the NPS may be able to account for spring flow depletion through use of its reserved right for reservation purposes, if the use and depletion quantities happen to equate.

In any selection of an alternative, NPS management must inform the community that it cannot rely upon NPS water deliveries due to the operation of law and policy. If continued reliance is placed upon the NPS water supply, either the NPS will have to provide it in perpetuity or some citizens will experience significant loss of property value. No matter the alternative selected, when an action is contemplated it would be wise to have legal counsel review the plan and verify or reject the foregoing analysis.

APPENDIX I

Spring Inventory and Monitoring Project Statement

PROJECT NUMBER: GRCA-N-

TITLE: SPRING INVENTORY AND MONITORING

SUBPROJECT TITLE:

FUNDING STATUS:

SERVICEWIDE ISSUES:

CULTURAL RESOURCES TYPE CODE:

10-238 PACKAGE NUMBER:

PROBLEM STATEMENT:

Groundwater pumping from a new well, and proposed wells, near the town of Tusayan, AZ could impact springs below the South Rim of Grand Canyon. It is not possible to predict the extent of impacts with certainty. Water is very limited in this area, so the loss of spring flow would seriously damage GRCA resources. A spring and stream flow monitoring program should be initiated to establish baseline flow data, and document any impacts that might occur.

Tusayan, AZ is a small community adjoining GRCA on the south, located along US Highway 180. The community has never had a local water supply, relying on water purchased and trucked in from Flagstaff, Williams and/or GRCA as available. Water sales by the park to Tusayan has twice been the subject of congressional action. The limited supply and cost of water has curtailed community growth. Development concepts have been prepared in the past, but construction has never started due to lack of inexpensive, adequate water supplies.

GRCA water can be supplied to Tusayan under Public Law 954-586. Water originates at Roaring Springs on the North Rim and is conveyed to the South Rim via the Transcanyon Pipeline. The pipeline was constructed in the 1960's and recent examination reveals that abrasion has weakened the pipe, indicating that the pipeline should be replaced in the next few years. The pipeline capacity is adequate for GRCA needs, but insufficient to supply expanding demands of Tusayan.

The Squire Inn at Tusayan has recently completed a successful water well. The well is reported to be about 3,000 feet deep, producing from the Redwall/ Muav Formations. Specifics of the well have been held private. The potential to acquire much greater quantities of water, at reasonable costs, has prompted new development plans which include the drilling of new wells. New development plans include land exchanges with the Forest Service to provide additional privately owned property to the Tusayan area and construction, including housing complexes.

Springs and streams along south rim, though small, are important

GRCA resources. They support riparian and aquatic habitats that are rare and very productive in this arid landscape. As water sources they are critically important for wildlife and hikers that are topographically isolated from the Colorado River.

US Geological Survey Water-Supply Paper 1475-C contains geohydrologic information indicating that GRCA springs and seeps are controlled by the hydraulic properties of the geologic formations in combination with faults and folds. There are at least 11 springs below south rim between Cataract Canyon and Little Colorado River, and numerous smaller seeps. All of them discharge from near the Muav/Bright Angel Shale contact. For example, Indian Garden Spring (historically used for South Rim water supply) has the largest flow of any spring known on the South Rim, and is located on the Bright Angle Fault plane, producing from the Muav Formation. Also, Hermit Spring which is the second largest spring produces from the Muav Formation.

All aquifers are considered as perched ground water systems, with the major aquifer being the Redwall/Muav Formations. This is the target aquifer for proposed wells at Tusayan and provides the yield of major springs along the South Rim. The conceptual model of ground water flow is rainfall percolating from the surface downward through the various formations. Where formations retard downward flow, some water flows laterally while some water continues to migrate deeper. Laterally flowing water near the
South Rim may flow north to the South Rim or to the south.

Wells drilled at Tusayan will penetrate perched aquifers as drilling proceeds to the Redwall/Muav. The open bore hole will allow perched water to drain continuously, dewatering the perched aquifers. However, it is believed that future stipulations to seal the annulus between casing and formations with cement will prevent impacts to springs/seeps derived from formations above the Muav.

The few small springs/seeps stratigraphically below the Muav may be subject to impact by ground water withdrawal from the Muav, which could reduce downward percolation of waters to the lower formations.

Potential impacts to GRCA springs/seeps along the South Rim exist from ground water pumping of the present and any new wells at Tusayan. A recent study Montgomery & Ass., contracted by a potential Tusayan developer, regarding Coconino Plateau ground water has been presented to NPS by Earl Montgomery. Mr. Montgomery stated that ground water pumping from the Coconino Plateau area would be reflected by equal amounts of reduced spring flow from the aquifer system. Although the major discharge point for the Muav aquifer is Havasu Spring located on the Havasupai Indian Reservation, impacts to GRCA springs are indicated by Montgomery's model. The proximity of GRCA springs to Tusayan wells is an important physical factor.

The well at Tusayan is believed to be the first disruption to

natural ground water conditions. The well yield is unknown but suspected to be minimal in supplying a hotel.

A spring/seep flow monitoring program should be established to provide background information about pristine conditions and to detect impacts on natural resources in GRCA. The program consists of four steps: inventory, feasibility assessment, installation of continuous monitoring equipment, and contracting with USGS for continuous monitoring services.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY:

The following activities pertain to springs/seeps issuing from or below the Muav.

1. Inventory

Water Resources inventory work done in the 1970's is believed to have identified all springs/seeps along the South Rim. The information gathered is predominately location and qualitative descriptions that are insufficient for our current needs. The primary objective is to determine if flow can be measured accurately and if the spring should be included in the monitoring program. Sources should be revisited by park staff to obtain these data. The new park hydrologist will assist other park staff in this task.

Additional inventory work which should be accomplished includes: plotting spring locations on the new 7 1/2 minute USGS topo maps; identifying spring locations with global positioning technology and photographing the site and the supported vegetation resource in color and black and white. Where available, aerial photographs can be used to map the extent of vegetation.

2. Feasibility Assessment

In combination with the inventory a determination of the feasibility of monitoring should be made. This feasibility study will require evaluations of flow magnitude, site condition which will influence the technical approach to monitoring, and size of vegetated area. If the flow is below about 10 gallons per minute and other factors are present, the source should be considered for twice yearly monitoring by park staff.

If the flow is above about 10 gallons per minute, consideration should be given to establishing a continuous monitoring station. Four such sources are listed in the USGS report, these being Indian Gardens, Hermit, Cottonwood, and Grapevine Springs. Also, Burro Springs has been suggested as a good possibility due to reported excellent spring opening conditions. Consultation or reevaluation may be needed in

this task, which could provided by Water Resources Division (WRD) and/or USGS.

Flow monitoring can be complicated by flash flooding, changes in channel morphology and diffuse flow at some sites.

3. Installation of Continuous Monitoring Station

For those springs selected in Item 2, this will provide for the installation of gaging stations including a control, and instrumentation. Designs can be provided by WRD or USGS, with actual construction to be completed by the USGS in consultation with and assistance from the park.

At this time, the only spring known to be physically compatible for this monitoring is Indian Gardens.

4. Continuing Monitoring Services

It is recommended that operation of stations and compilation of records for continuous monitoring stations be arranged through the US Geological Survey. This is recommended because (1) their staff are very familiar with all aspects of such tasks which insures proper field procedures, (2) compilation of the such records are a normal office task and any and all adjustments are known and properly applied, (3) records become a part of the USGS permanent data base and are published, and (4) the legal autonomy of the USGS would serve us well if legal conflict arises in the future.

BUDGET AND FTEs

Funding requirements for continued monitoring in Years 2-4 and beyond will depend on the feasibility of installing gaging stations, which will not be known with certainty until after the first year. The funding request will be refined at that time.

Continued spring and stream flow monitoring is a long-term need that should be part of the park base.

----------FUNDED ----------

Source	Act Type	Budget ($1000)	FTEs
Year 1			
Year 2:			
Year 3:			
Year 4:			
	Total:		

---------- UNFUNDED ----------

	Source	Act Type	Budget ($1000)		FTEs
Year 1	WRD				
		Item 1	2.0		
		Item 2	4.0		
		Item 3	30.0		
		Item 4	10.0	per year	(includes recorder)
Year 2:		Item 4	10.0		
Year 3:		Item 4	10.0		
Year 4:		Item 4	10.0		
		Total:	76.0		

(OPTIONAL) ALTERNATIVE ACTIONS/SOLUTIONS AND IMPACTS:

COMPLIANCE CODE(s):

EXPLANATION: